CHAPTER 3
RESEARCH METHODOLOGY

3.1 THE STUDY
3.2 THE SAMPLE DESCRIPTION
3.3 THE TOOLS FOR DATA COLLECTION
   3.3.1 Tool for Measuring Organizational Performance and Productivity
   3.3.2 Tool for Measuring ERP Success in Implementation Phase
   3.3.3 Tool for Measuring Other ERP Constructs
3.4 THE TOOLS FOR DATA ANALYSIS
   3.4.1 Test for Normality
   3.4.2 Test for Reliability and Validity
   3.4.3 Paired t-Test
   3.4.4 Arithmetic Mean
   3.4.5 Independent Sample t-Test
   3.4.6 ANOVA
   3.4.7 Percentage Analysis
   3.4.8 Structural Equation Modeling
This chapter outlines the description of research methodology used in the present study. The chapter has sections on the nature of the study, sample, tools for data collection and tools for data analysis.

3.1 THE STUDY

The present study is an exploratory investigation. The study is intended to determine the effects of ERP on organizational performance and productivity. Since, the purpose of the current research was to identify the effects in manufacturing companies, the empirical method was chosen for assessing the primary data. The choice of independent and dependent variables was based on the rationale of the study and outcome of literature review. Imperative dimensions of organizational performance and productivity were explored on the basis of literature review using BSC model (Internal Process; Innovation, Learning and Growth; Financial and Customers, Suppliers and External Agencies).

The study then moves to study the impact of demographic variables on changes caused by ERP on organizational performance and productivity. It is also important to measure the success of ERP in implementation phase since; changes caused by ERP system on organizational performance and productivity can be highly affected by the successful implementation of the project. On the basis of literature review, project components were identified for assessing the success of an ERP system in the implementation phase. The study then tries to analyze the relationship of different components of ERP in implementation phase and changes caused by ERP on organizational performance and productivity. The study then throws light on the general characteristics of ERP with respect to manufacturing companies.
3.2 THE SAMPLE

The study is directed to companies that had already implemented an ERP system. Specifically, the survey was administered to employees of the manufacturing companies who were involved in implementation process and are now the end-users. Four criteria guided the selection of the cases: (a) the firm should be in manufacturing, (b) the firm should be located in Pithampur or Dewas region (c) it must have been using an ERP system for at least 1 year, and (d) it must have been using the system in at least two business processes.

Data was collected from 12 manufacturing organizations that fulfilled the above criteria’s and the sample of the study constituted of 202 individuals working in these manufacturing companies. Using non-probabilistic judgemental sampling, a total of 237 surveys were collected, after several follow-up e-mails and phone calls. The reliability control has shown that 13.8 percent of respondents were unreliable, as some questions were left unattended. Moreover, in some cases, the observed responses were artificially inflated as a result of respondents’ tendencies to respond in a consistent manner. The sample of 202 respondents was finalized with respect to the following classifications:

<table>
<thead>
<tr>
<th>Gender</th>
<th>Male</th>
<th>181</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>21</td>
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<table>
<thead>
<tr>
<th>Age</th>
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<tbody>
<tr>
<td></td>
<td>20-35</td>
<td>96</td>
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<tr>
<td></td>
<td>36-50</td>
<td>91</td>
</tr>
<tr>
<td></td>
<td>51-65</td>
<td>15</td>
</tr>
</tbody>
</table>

| Educational Qualification | Graduate | 61 |
|                          | Post Graduate | 127 |
|                          | Diploma | 14 |

| Position in company | Junior level | 38 |
|                     | Middle level | 109 |
|                     | Senior level | 55 |

Table 3.1: Classification of Respondents Demographics Profile
3.3 TOOLS FOR DATA COLLECTION

Review of literature indicated unavailability of appropriate instrument for measurement of effectiveness of ERP on organizational performance and productivity. Therefore, separate tools for measuring effects of ERP on organizational performance and productivity and different components related to ERP were self-developed and administered. Primary data was collected through personal meetings, e-mails and telephonic conversation. The additional data needed to support the study was collected from the additional sources like online publications, journals, books and websites of ERP vendors. Markus et al. (2000) says that ERP success can be measured in three phases: project phase, implementation phase and post implementation phase. In our study, we have merged characteristics of project phase in the implementation phase. Hence, the instruments have been designed for two phases: implementation and post implementation phase. The description of the instruments, used to collect the primary data is as follows:

3.3.1 Tool for Measuring Organizational Performance and Productivity

Basically, a combination of performance indicators was used to determine the effectiveness and productivity of an ERP system in an organization. A method for determining the relationships between the objectives of the ERP project and the performance indicators of an organization is developed, so that they have common features and evaluation standards. It seems that the key to answer the persistent question of IT’s contribution to organizational performance is to be found in the measurement issue (Barua et al., 1995). Literature revealed that some of the studies related to organizational performance have taken BSC model as a foundation. The present study also considered BSC as a basis of evaluating the organizational performance and productivity, since; it increases the completeness and the quality of ERP implementation reports and raises the awareness for relevant factors.
However, financial performance factor of BSC model was not measured, since the manufacturing organizations were reluctant in sharing the financial data and data available on internet was for the entire group of organization, which could not be taken for the analysis. Elragal and Serafi (2011) suggested that financial benefits have been analyzed many times before and do not give a direct contribution of the effect of the ERP system in specific. Velcu (2007) also suggested that a qualitative rather than a quantitative approach, focusing on operational and intangible benefits can better outline the direct relationship between the ERP system and the business performance. According to DeLone and McLean (1992), Jacobs and Bendoly (2003), and Kennerley and Neely (2002) also, system success is measured in language of financial costs and benefits, but, such measures are often not possible because, of the problems in quantifying intangible impacts and leaving the IS effect from other environmental variables that affect organizational performance.

Also, given that the phenomenon under study, effects of ERP, is complex and that one requires a deeper understanding of it in its actual context, a qualitative methodology is more appropriate (Bourlakis and Bourlakis, 2006). Hence, the focus of this paper will be on the operational and intangible gains resulting from ERP implementation (which will be operationalised by many variables tested in this study). The performance indicators chosen were actually taken by the managers and ERP vendors through the interviews, together with the literature review.

For measuring the effect of ERP on organizational performance and productivity, the list of 67 items were formed. Because, the study incorporated tools that were new to IS research, further retesting of these tools was deemed necessary to assess their robustness to a different population of firms, and to derive confidence in subsequent analysis, a pilot survey was executed before conducting the main survey. The purpose of the pilot survey was to examine whether or not the proposed model was well developed and suitable to analyze ERP success. The conceptual ERP success model and contents of the main
survey were modified based on the results of the pilot survey and it provided 62 items that were selected for the submission to the panel of judges for assessing content and construct validities. The final list on the basis of the frequency of choices of the judges comprised of 56 items (with 84% acceptance).

Subsequently, these 56 items of effectiveness were allocated into the three facets of the Balanced Scorecard namely Internal Processes; Innovation, Learning and Growth; Customers, Suppliers and External Agencies in order to construct the effectiveness framework of ERP system. These indicators in the tool were employed on 7 point Semantic Differential scale ranging from very less to very high for both before ERP implementation and after ERP implementation.

After ensuring the construct validities of the items selected, the reliability of the tool was determined by Cronbach’s alpha method. Reliability coefficient alpha (α) was found to be 0.95 for implementation stage and 0.94 for organizational performance indicators, showing excellent reliability of the tool. Hinton et al. (2004) have suggested four cut-off points for reliability, which includes excellent reliability (0.90 and above), high reliability (0.70-0.90), moderate reliability (0.50-0.70) and low reliability (05.0 and below). The closer the alpha is to 1.00, the greater the internal consistency of items in the instrument being assessed (George and Mallery, 2006). When a tool is developed for a particular situation and no other standardized instrument is available, the reliability index based on reliability coefficient can be taken as equivalent to validity of the tool (Garret, 1981). Since, the tool developed for the present study was unique in nature, the validity was taken to be reliability index.
Research Methodology

Profile

Tool: Organizational Performance Indicators Questionnaire
Author: Self
Nature: Verbal
Structure: 56 items, 7-point Semantic Differential scale.
Duration: No time limit
Reliability: 0.94
Validity: 0.97

Description

1. The tool is self-administering
2. The subject is asked to interpret each statement himself/herself.
3. The subject is expected to tick (✓) mark on any of one to seven choices given against each statement. The choices range from very low to very high for both pre-ERP and post-ERP stage. There is no right or wrong answer hence, each subject is free to give his/her opinion on the statement.

Scoring

1. Scoring is done manually.
2. Each item or statement awarded 1 for very less and 7 for very high in both (pre-ERP and post-ERP) stages.

3.3.2 Tool for Measuring ERP Success in Implementation Phase

The degree of project success should be assessed in terms of 5 components that are mainly required to produce a computer-based information system i.e hardware (central processing unit and all of its support equipments), software (computer programs and the manuals), people (vendor, user, top management, consultant), data (facts used by
programs to produce useful information) and procedure resources (policies administering operation of a computer system).

Since, ERP system is a computer-based information system, hence we have taken the same components for our study. Questions were developed after the extensive literature review of the critical factors. For measuring the success of ERP in implementation phase, the list of 48 items was formed. Screening by removing the irrelevant items and decision of the panel of judges comprised of 37 items (with 78% acceptance). These items in the tool were employed on 5-point Likert scale ranging from strongly disagree to strongly agree. After ensuring the content of the items selected, the reliability of the tool was determined by Cronbach’s alpha method and the reliability coefficient alpha (α) was 0.95 showing high reliability of tool.

Profile
Tool: Implementation Phase Questionnaire
Author: Self
Nature: Verbal
Structure: 37 items, 5-point Likert scale.
Duration: No time limit
Reliability: 0.95
Validity: 0.975

Description

1. The tool is self-administering
2. The subject is asked to interpret each statement himself/herself.
3. The subject is expected to tick (✓) mark on any of one to five choices given against each statement. The choices range from strongly disagree to strongly agree. There is
Research Methodology

no right or wrong answer hence, each subject is free to give his/her opinion on the statement.

Scoring

1. Scoring is done manually
2. Each item or statement awarded -2 for strongly disagree, -1 for disagree, 0 for not sure, 1 for agree and 2 for strongly agree.
3. The score are distributed with approximately equal variance around the midpoint of tool. Higher the score from mid point or median, high is the agreement during ERP implementation, whereas lower the score, low is the agreement.

3.3.3 Tool for Measuring Other ERP Constructs

IS are technology-based innovations that are created and used by individuals, organizations, and societies (Allen, 2000). According to Grabski and Leech (2011), researchers should also take into consideration industry specific factors. Hence, five other main constructs were identified.

A. Extent of ERP implementation: Functional scope, Geographical scope and Organizational scope
B. ERP installation features: Process for ERP installation (BPR and customization), Time taken for ERP implementation.
C. ERP features: Name of ERP software, Database, Operating System.
D. Size of the company
E. Modules of ERP
3.4 TOOLS FOR DATA ANALYSIS

After collecting the data, the following statistical tools using window based Statistical Package of Social Sciences (SPSS 16.0), PLS Graph and MS Excel 2007 were employed for data analysis and to arrive at meaningful conclusions.

3.4.1 Test for Normality

As the subsequent experiments required the assumption of normal distribution of the sample as the pre requisite for the analysis, it became necessary to test the veracity of the assumption of normal distribution of collected data. Normality test statistics by Kolmogorov-Smirnov test assess whether a particular distribution differs significantly from normal distribution (Carver and Nash, 2006). Thus, the responses of total 202 respondents were tested and significance value was found to be 0.200 (greater than 0.05) and indicated that the distribution does not differ significantly from normal distribution. This inferred that the assumption of normality with respect to the sample chosen was valid. Hence, the experiments and analysis could be carried out with the chosen sample (Appendix C1).

Skewness and Kurtosis as the measures of deviation from normality were also calculated. A value between ±2.0 for both skewness and Kurtosis is acceptable for showing normality of data (George and Mallery, 2009). The value of skewness was found to be -0.109 and for Kurtosis, it was found to be 1.247. In both the cases, value fell within acceptable range of ±2.0. The smaller values of standard error for kurtosis (0.341) and skewness (0.171) also indicate greater stability of data. The values related to skewness and kurtosis and the histogram of frequency distribution are shown in the appendix C2 and C3 respectively.
3.4.2 Test for Reliability and Validity

Reliability of the measures was assessed with the use of Cronbach’s alpha. Cronbach’s alpha allows us to measure the reliability of different variables. As a general rule a coefficient greater than or equal to 0.7 is considered acceptable and is a good indicator of reliability. In the present study, the reliability of the questionnaire comes to be 0.94 and 0.95 for organizational performance indicators and components of implementation phase respectively (Appendix B). Hence, the questionnaire was considered reliable for the study.

3.4.3 Paired t-Test

Paired t-test checks the confidence intervals for the difference between a pair of means (Armitage and Berry, 1994; Altman, 1991). This test compares the means of two variables by calculating the difference between the two variables and tests to see if the average difference is significantly different from zero. A paired t-test measures whether means from a within-subjects test group vary over 2 test conditions. The paired t-test is commonly used to compare a sample group’s scores before and after an intervention. First, the paired t-test is applicable when measuring how a static group measuring organizational performance performs in two conditions and this requirement is met. Second, the paired t-test is appropriate when the independent variable is dichotomous. In our experiment, the two test conditions, (presence of a ERP system or lack thereof) fulfil the requirement.

Testing of matched pair permits us to control for confounding macroeconomic or industry influences. Since, 202 employees participate in the experiment, so the study is marginally safe in assuming the dependent variable followed a normal distribution (the central limit theorem proves distribution is normal with a sample size of 30 or more). Thus, we can say that paired t-test is valid in our analysis.
3.4.4 Arithmetic Mean

Arithmetic Mean is a mathematical representation of the typical value of a series of numbers, computed as the sum of all the numbers in the series divided by the count of all numbers in the series. The success of ERP in implementation phase was determined by computing the mean value of the responses.

3.4.5 Independent Sample t-Test

An Independent sample t-test is a hypothesis test in which we compare data from one sample to a data of another sample. In our study, for measuring the role of gender on the changes caused in organizational performance and productivity due to ERP system, independent sample t-test was used.

3.4.6 ANOVA

To explore the effect of age, educational qualification and designation of an ERP user on the change in organizational performance and productivity caused due to ERP system, Univariate Analysis of Variance (ANOVA) was applied. When the sig value (p-value) is less than 0.1, it means that there is a statistically significant association between the dependent and independent variables and the null hypothesis is rejected at 10% level of significance, otherwise accepted. If the p-value is more than 0.10, then the model chosen is not statistically significant (Georage and Mallery, 2006)

3.4.7 Percentage Analysis

Percentage analysis is the method to represent raw streams of data as a percentage (a part in 100 - percent) for better understanding of collected data. In order to determine the
difference in the general characteristics of ERP in different manufacturing companies, percentage analysis was used.

### 3.4.8 Structural Equation Modelling

PLS-Graph was used to test the hypothesized relationships among the study variables. The choice was motivated by several considerations. PLS is a non-parametric estimation procedure (Wold, 1982). Its conceptual core is an iterative combination of principal components analysis relating measures to constructs, and path analysis capturing the structural model of constructs. The structural model represents the direct and indirect causal relationships among constructs. It can be used to estimate models that use both reflective and formative indicators, is more appropriate for analyzing moderating effects because traditional techniques cannot account for measurement error in exogenous constructs (Fornell and Bookstein, 1982) allows for modelling latent constructs under conditions of non-normality, and is appropriate for small to medium sample sizes (Chin, 1998a, 1998b; Chin and Newsted, 1999).

According to Diamantopoulos and Winklhofer (2001), Jarvis et al. (2003) and MacKenzie et al. (2005), there is a growing need in modeling so-called formative construct. In recent years, formative measurement has received increasing attention in various disciplines including organization research (Podsakoff et al., 2003) and information systems (Petter et al., 2007). Extant literature on formative measurement is primarily of a technical nature focusing on issues such as model specification, identification, and estimation (Bollen and Davis, 2009; Cenfetelli and Bessellier, 2009; Diamantopoulos and Winklhofer, 2001; Petter et al., 2007).

According to Churchill's (1979), researchers traditionally treat the relationship between a construct and its measures on the basis of classical test theory, which assumes that each measure is a reflection or manifestation of the underlying construct, one type of multi
item measures, namely scales comprised of reflective indicators. As a result, these
measures are referred to as “reflective” measures of the construct (Fornell and
Bookstein, 1982), and the construct is referred to as a “latent” variable (MacCallum and
Browne, 1993). However, there is growing recognition that some measures may actually
be determinants or causes of a construct, rather than manifestations of it (Bollen and
Lennox, 1991; Edwards and Bagozzi, 2000; MacCallum and Browne, 1993). These
measures are referred as “formative” measures of the construct (Fornell and Bookstein,
1982), and the construct is referred as a “composite” variable (MacCallum and Browne,
1993).

Podsakoff et al. (2006) review four criteria that differentiate reflective and formative
measurement models. The first characteristic of formative measurement models is that
the construct is determined by its measures, and changes in the measures are expected to
produce changes in the construct. In contrast, the characteristic of reflective measurement
models is that the construct underlies the measures, and changes in the construct are
expected to cause changes in the measures.

The second criterion relates to the interchange ability of the measures at the conceptual
level. Because formative measures are exogenous determinants of the construct and may
capture unique aspects of its domain, they are not necessarily expected to be
interchangeable. As a result, removing any of the formative measures of a construct may
alter the conceptual domain of the construct and subsequently result in construct
measurement deficiency (Bollen and Lennox, 1991). In contrast, because reflective
measures are viewed as equivalent manifestations of the same construct, they are
expected to be interchangeable and assuming that they are equally reliable, removing any
of them should not have a significant impact on the conceptual domain of the construct.

The third criterion relates to the covariance of the measures (Bollen, 1984; Bollen and
Lennox, 1991; Jarvis et al., 2003). Since each formative measure is an exogenous
variable that may capture a unique aspect of the construct’s domain, these measures need not be expected to covary at a high level with one another. Indeed, as noted by Bollen (1984) measures of a composite construct may be positively, negatively or not related to each other. In contrast, since all of the measures of a reflective construct are expected to be interchangeable manifestations of the same construct, these are expected to covary at high level.

The fourth criterion relates to the similarity of the nomological networks of the measures (Jarvis et al., 2003; MacKenzie et al., 2005). As manifestations of the same construct, reflective measures are expected to have similar antecedents and consequences. As exogenous determinants of a construct, formative measures are not necessarily expected to have similar antecedents or consequences.